

SSL Essentials: Technology, Applications, Advantages, Disadvantages

Kevin Dowling, PhD
Vice President Innovation

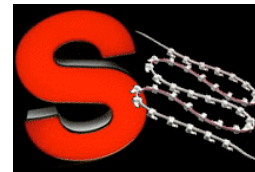
April 23, 2007

SSL Technology



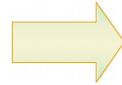
Indication to Illumination

- Monochrome Indicators
 - Traffic lights, automotive, exit signs etc
 - Portable appliances, cell phones, PDAs
 - Signage
 - Direct view displays; video screens
- Emerging Applications
 - Transportation: marine, auto, aviation etc.
 - Lighting niches
- Future
 - General Illumination



Lighting Sources

Conventional Lighting Sources



LED Lighting Source

- Incandescent



- Halogen



- Fluorescent



- Gas-discharge
(e.g neon)



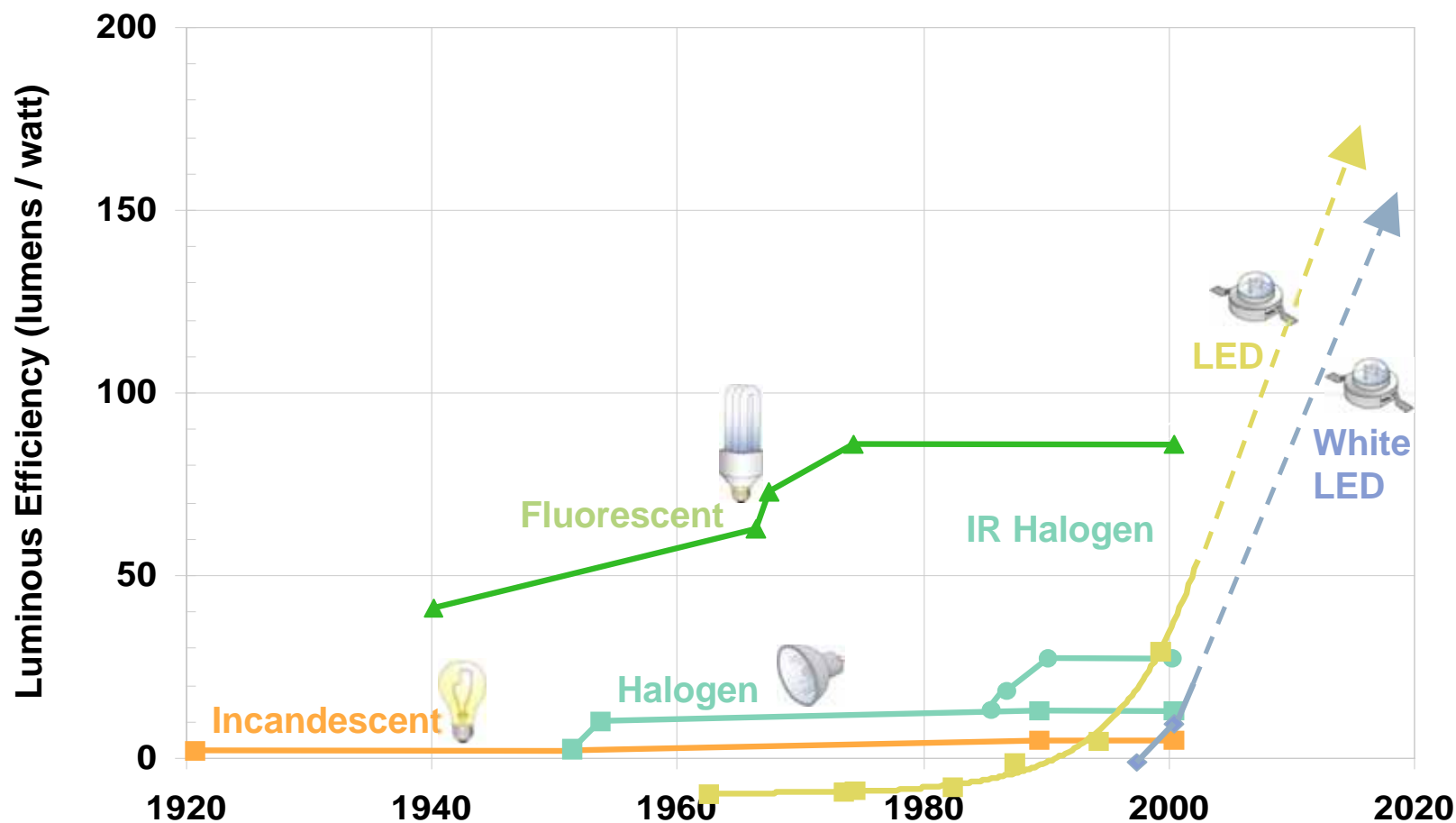
- Light emitting diodes (LEDs)



Benefits of LED Lighting

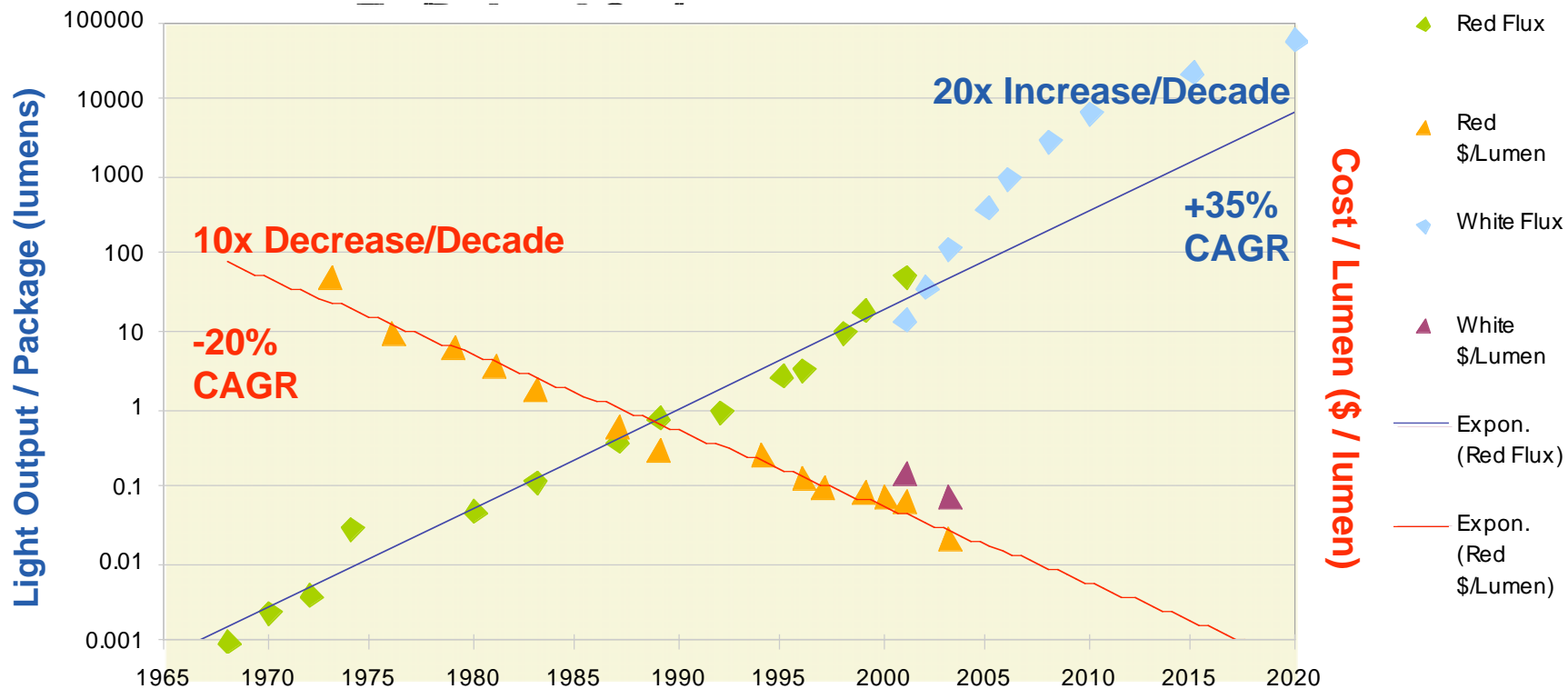
- Ultra long source life
- Low power consumption
- Low maintenance
- No UV or IR radiation
- Cool beam of light
- Digitally controllable
- Sustainability

Market Trends: LEDs Eclipsing Traditional Technologies



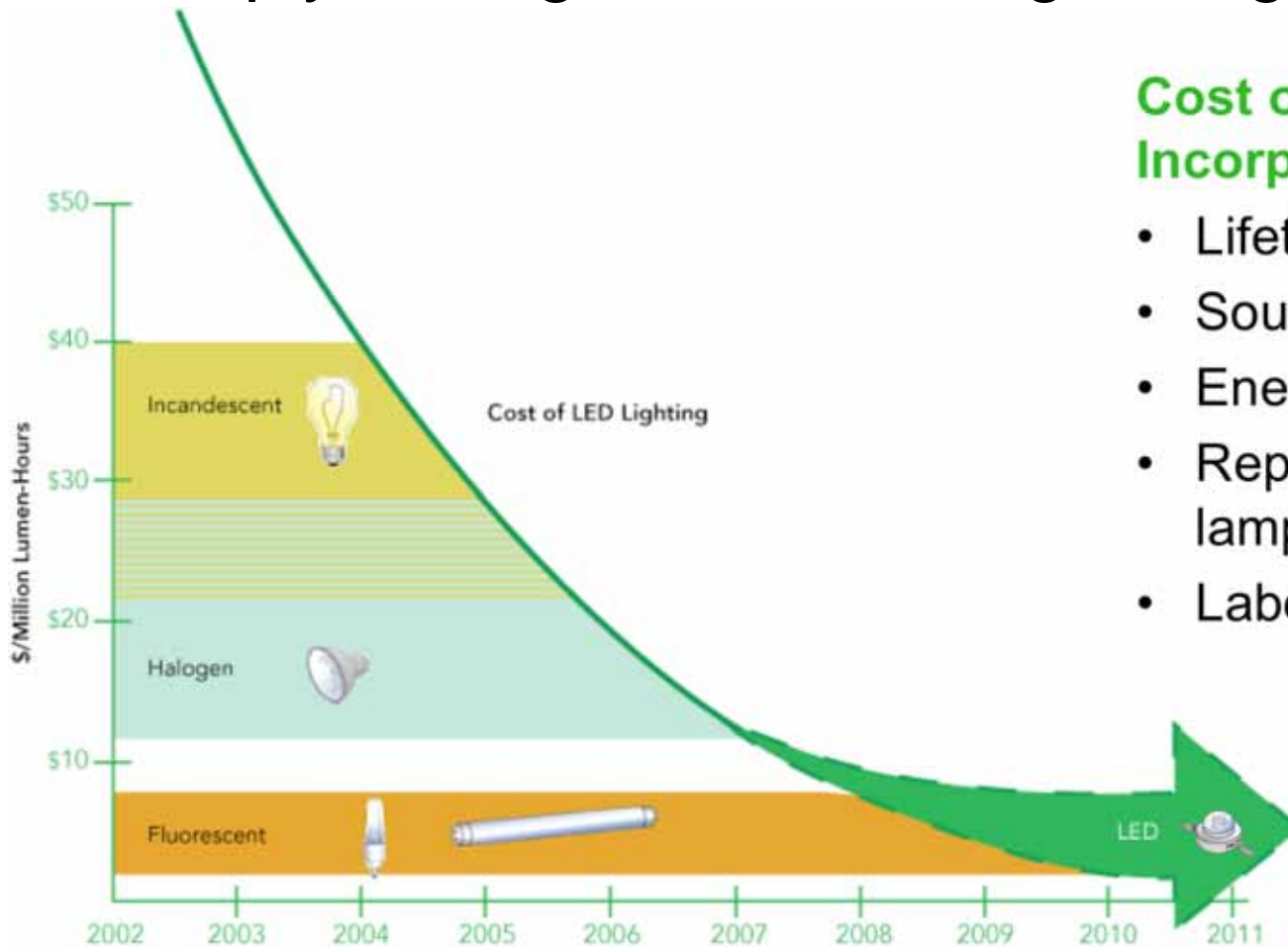
Source: Lumileds

Haitz' Law: LED Light Output Increasing/Cost Decreasing



Source: Roland Haitz & Lumileds

Market Trends: Sharply Falling Cost of Intelligent Light



Cost of Light Incorporates:

- Lifetime
- Source efficiency
- Energy cost
- Replacement cost of lamp/fixture
- Labor cost

Source: Color Kinetics; Research conducted with white LEDs only; Color Kinetics estimates, and are not indicative of future performance

Energy Conservation

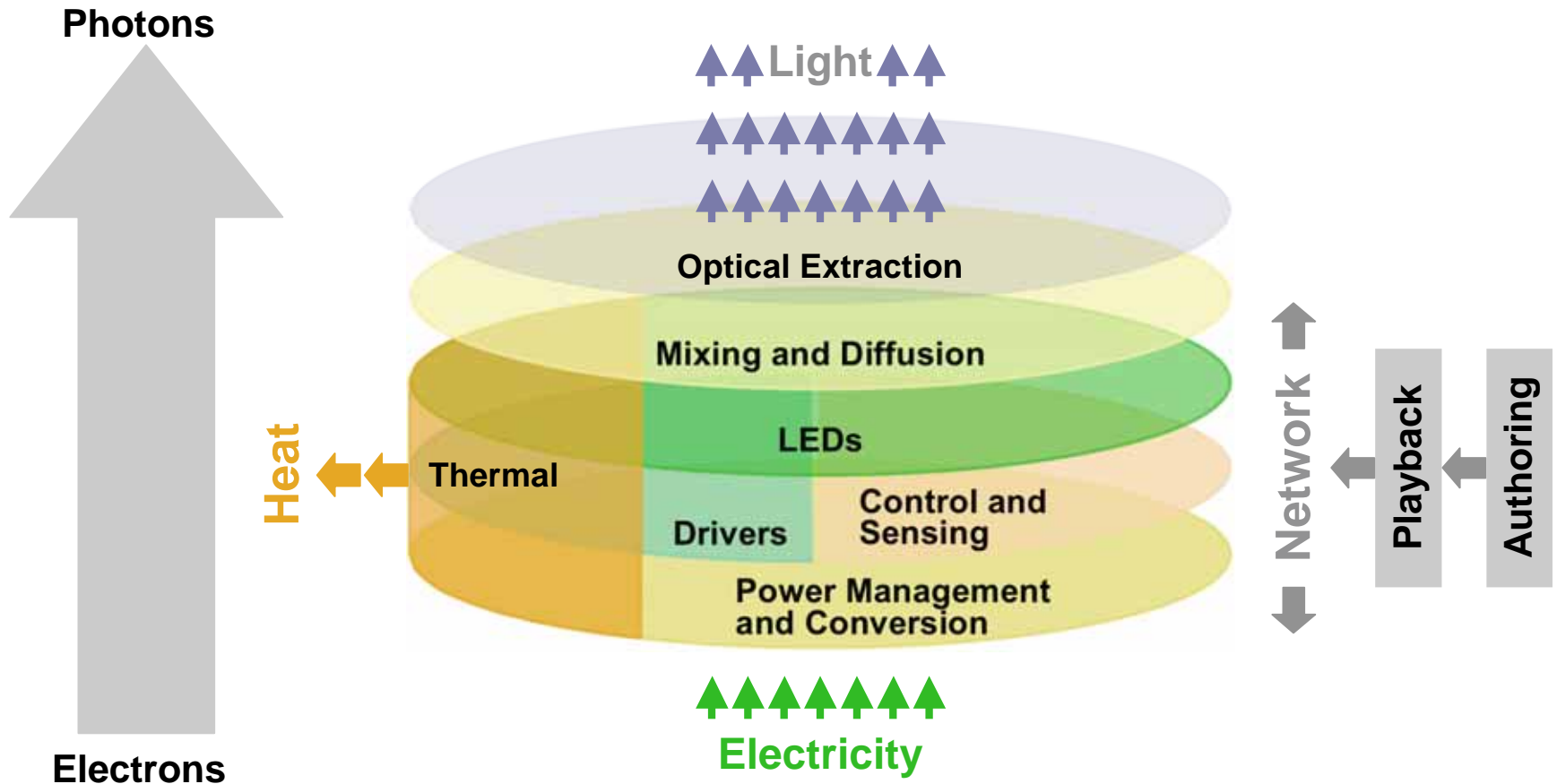
- Based on lamp and White LED manufacturers' data, commercially available *LED sources are four times more efficient than conventional incandescent and halogen sources*
- There are already laboratory *White LED sources that are 30% more efficient than linear fluorescent sources*
- Off-the-shelf LED sources are only 18-35% less efficient than compact and linear fluorescent sources today and *the gap is closing rapidly*. The trend is key, not the snapshot
- Lighting uses 20% of electricity used in US Buildings*
- Cascade effects: lighting adds heating loads in retail and commercial facilities*

* Source: US Department of Energy <http://www.eia.doe.gov/>

Market Trends: Energy Conservation

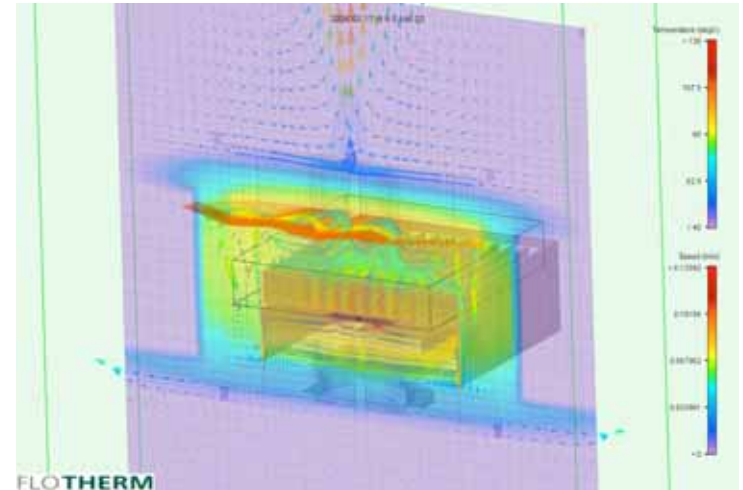
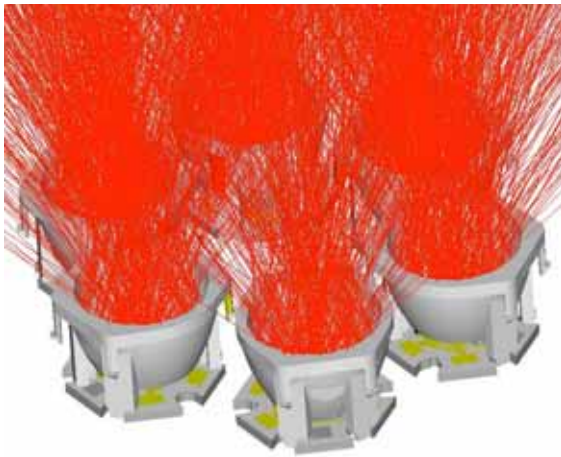
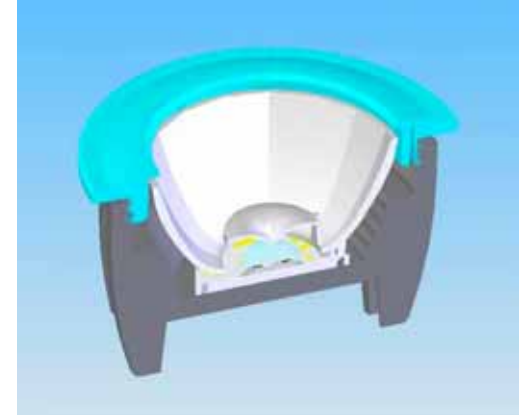
- CFL adoption: We must support interest in energy efficient light sources
- Additional LED benefits
 - Potentially better quality of light
 - Control capability including dimming and CT control
 - Longer lifetimes
 - No Mercury
 - Even small amounts of Hg require all fluorescents to be treated as haz waste upon disposal (I.e. California's Title 22)
 - LED light more easily directed.
- The scale is likely to ultimately tip in favor of LEDs

LED Lighting Systems: What's Involved



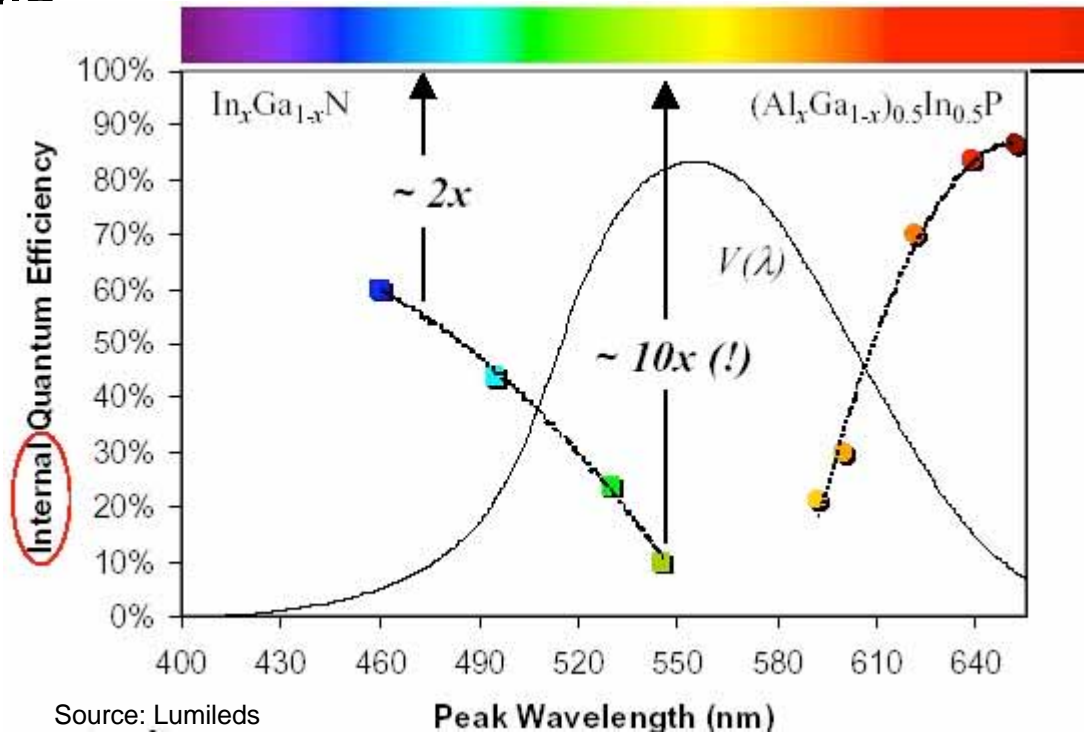
Technical Challenges

- Managing Systems
- Integrating Technologies

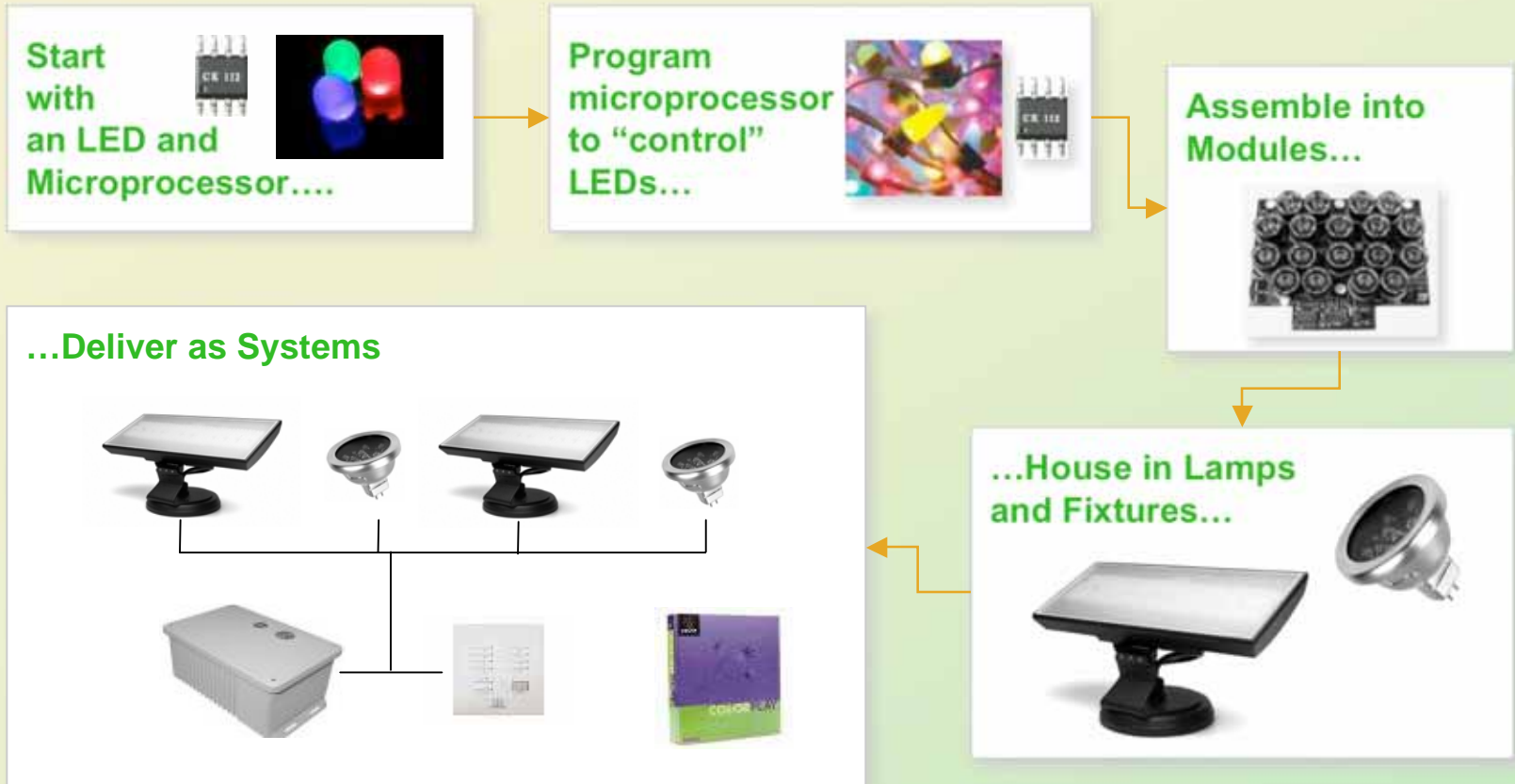


Technical Frontiers

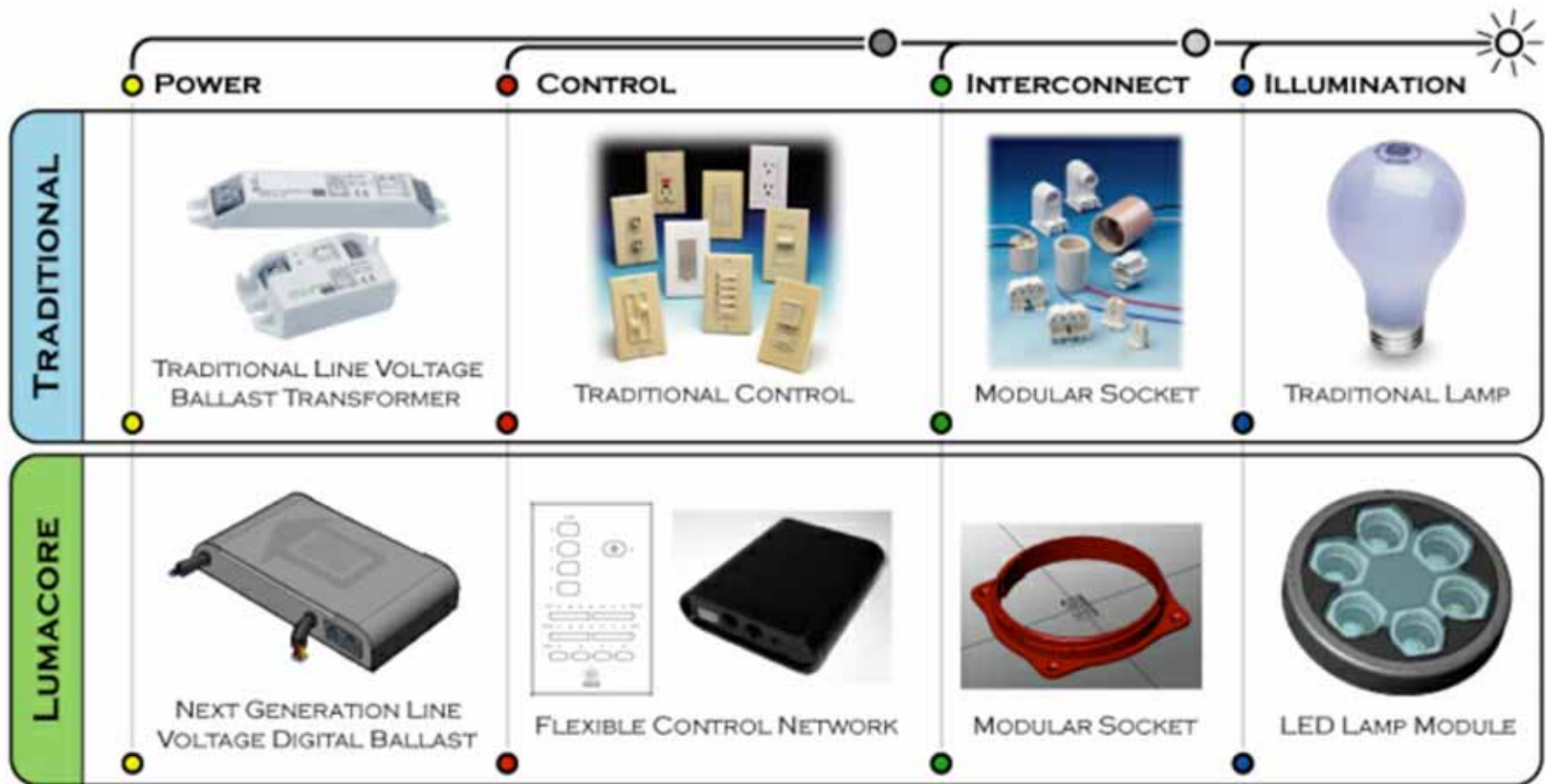
- Efficacy improvements
- 'Green Valley'
- Lower Cost Materials



Anatomy of an Intelligent LED Lighting Solution

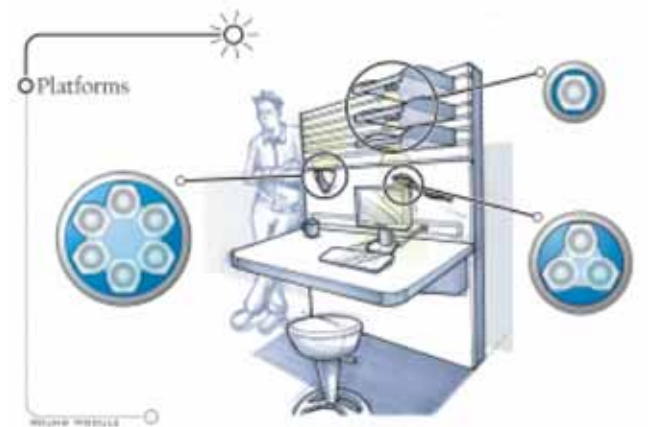
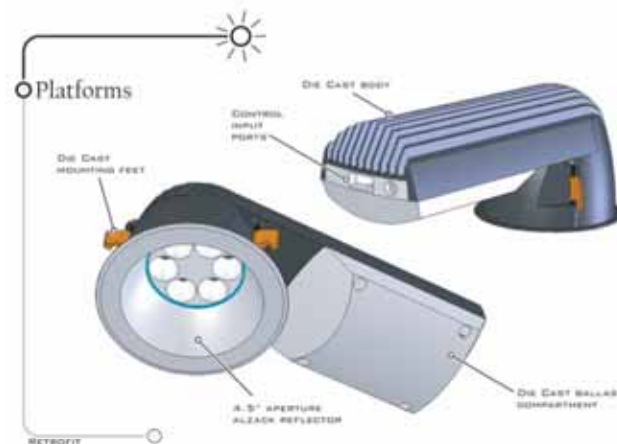
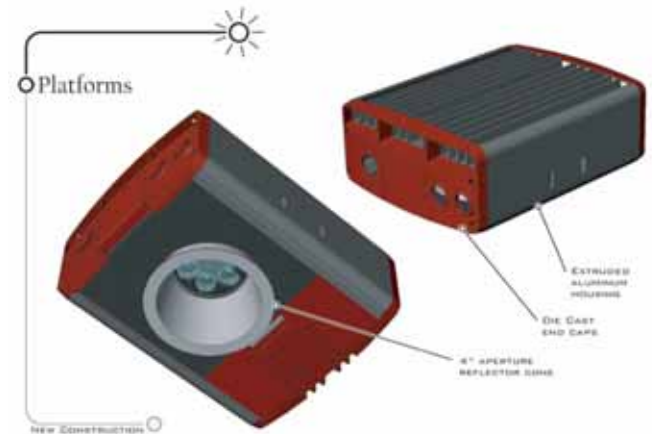


Anatomy of a Next Gen LED Lighting System



Re-inventing the Lighting System

The complete solution that will set a new standard form-factor for LED systems



Transforming Environments

- Color Effects
 - Light as entertainment
 - Light as atmosphere
 - Light as architecture
 - Video as lighting content
 - Light to increase sales*



**CK white paper highlights the changes in buyer behavior with the use of color digital lighting*

Transforming Environments

- Color Temperature Control
 - Optimize product aesthetics
 - Create a desired environment
 - Increase workplace productivity
 - Improve customer experience

- Single Color
 - Specify CT for specific applications
 - Fixed color dimmable



Assessment

There is nothing technically intractable or infeasible to achieving high quality, high performance lighting based on LEDs.

Costs will continue to drop

- Manufacturing improvements

- Economies of scale

- Production costs

SSL Applications



SSL and the Global Lighting Market

Global Lighting Market Size

(in billions) 2004/2005

Lamps	\$18
Fixtures	\$70
Total	\$88

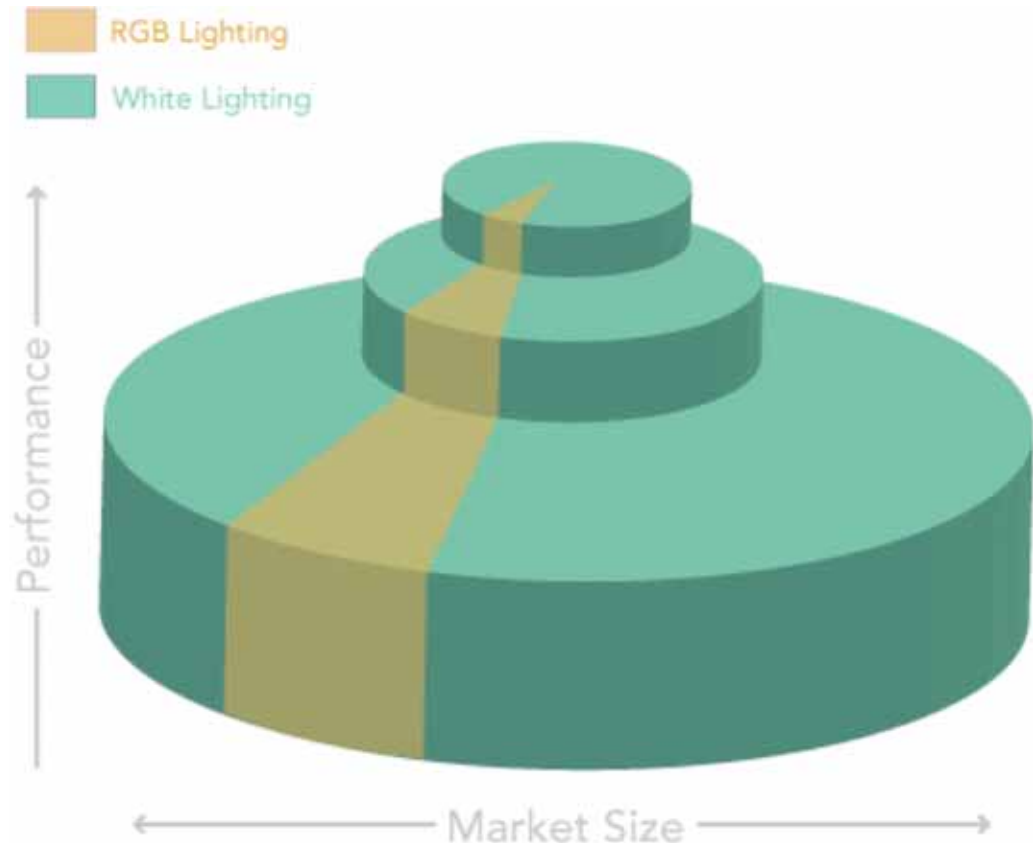
Source: Freedonia Group, Inc. Studies 2067-Lighting Fixtures & 2004 - Lamps

U.S. Lighting Market Size

(in billions) 2004/2005

Lamps	\$4.4
Fixtures	\$17.4
Total	\$21.8

Source: Freedonia Group, Inc. Studies 2067-Lighting Fixtures & 2004 - Lamps



Potential Addressable Market: \$20B to \$30B

Current SSL Markets



Architecture



Hospitality



Entertainment



Retail

Energy Conservation

- Los Angeles International Airport (LAX)
 - Expects to cut energy consumption by 75%
 - Annual electric bill from \$73K to \$18K
 - Expects to reduce annual maintenance costs from \$1M to \$20K
 - Based on CK calculation, entire cost of installation is recovered in ~28 months



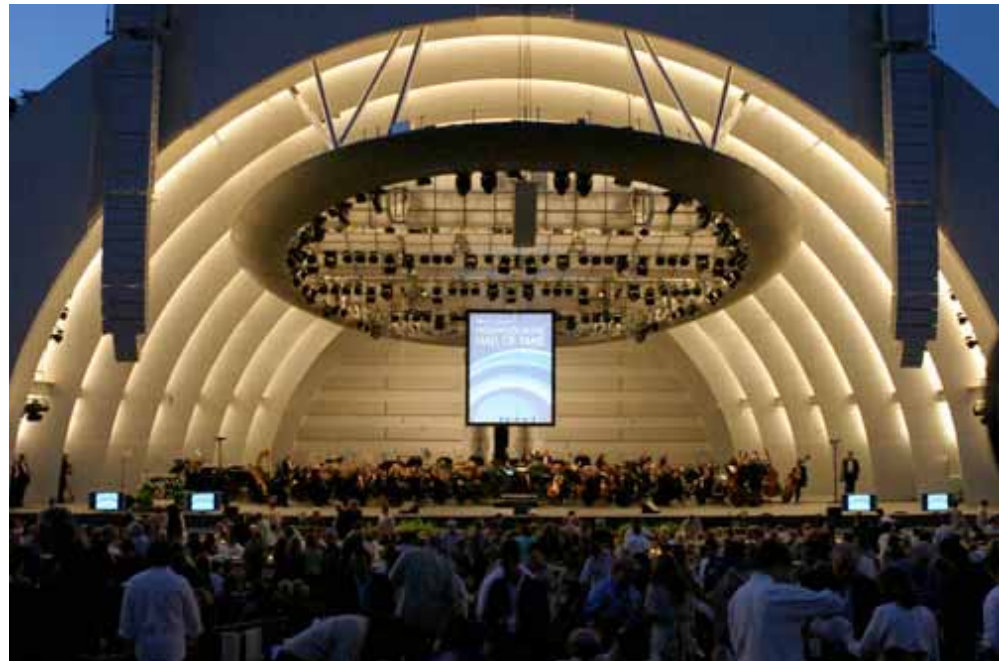
Market Trends: Energy Conservation

- Hardrock Hotel and Casino
 - Expects to reduce annual operating costs by \$41,000
 - Previous metal halide fixtures drew about \$18,000 per year
 - LED-based units projected to draw about \$1,900 per year
 - Previous fixtures cost about \$25,000 per year for maintenance, not including filters and ballasts
 - LED-based units are expected to run only \$600 per year for maintenance



Market Integration

- Verticals and Horizontals
 - Most industries evolve to horizontal stratification
 - In LEDs this could be
 - Substrates, Materials, tools
 - Wafers, Packages,
 - Optics, Thermal
 - Power, Drivers,
 - Lamps, Luminaires
 - Controllers
 - Systems



Applications

- Hospitality



Applications

- Hospitality



Retail

- Display
- Merchandising
- Low to Medium Illuminance



Architectural

- Outlining Buildings



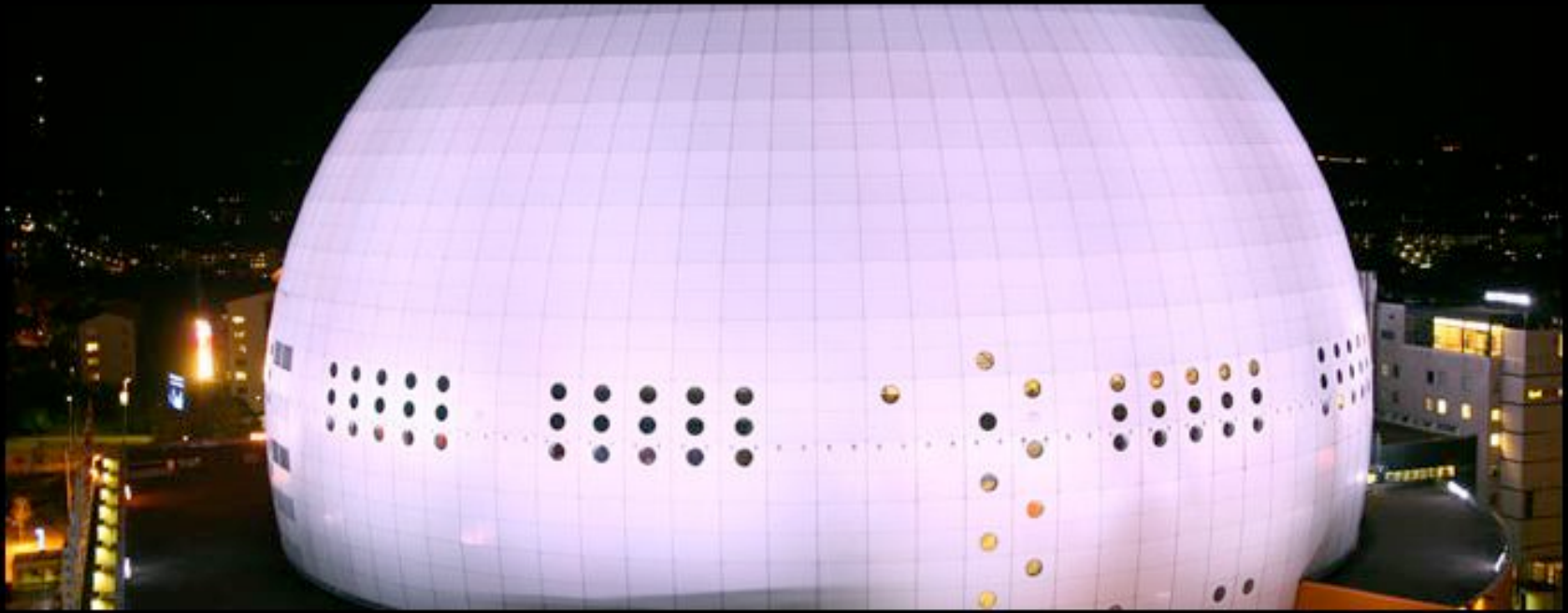
Museum

- White points of light



Architecture

- 110m diameter performance venue



SSL Added Value: Bridge Application

- Vibration
- Humidity
- Temperature
- Lifetime
- Cost of Maintenance



Technical versus Market Progress

- Many of today's technical issues are being addressed
 - Color (Temperature)
 - Efficacy
 - Quality of Light
 - Thermal
 - Binning
- If no improvement were made in LEDs today the market would still be growing.
- Laboratory to market is 18 months but market to substantive applications is longer

Migration

- Specifier business
 - Distribution, Representatives
 - Long sales cycle
 - Many players
 - Issue of Value Engineering
- Commercial business
- Retail

Old and New

- Efforts into research into traditional lighting diminishing over time. Mature.
- Ripe for change!
- Who imagined this?



SSL Features Enabling Mainstream Adoption

- *Real* efficacy parity or better with fluorescent sources
- Costs allowing two year or less ROI
- Standards for specifications
- But is this enough? Witness CFL history.

Standards

- Fast becoming real
 - Luminous Flux
 - Lumen Depreciation
 - Chromaticity
 - And more...



Education

A huge part of growing this market is education.

Benefits of SSL

Issues with current technology

How they work

Benefits *and* limitations



Disadvantages of SSL

- What is slowing adoption?
 - Cost
 - Fear
 - Another CFL
 - Another Fiber
 - The Right Products



Trends in Lighting

- Theater in retail
- Theater in home
- Layers of light
- Lighting *design*
- *Not just engineering*



What's Changing?

- Everything
 - Lighting Technology
 - Lighting Applications
 - System Models
 - Business Models



Real Danger: Hyperbole

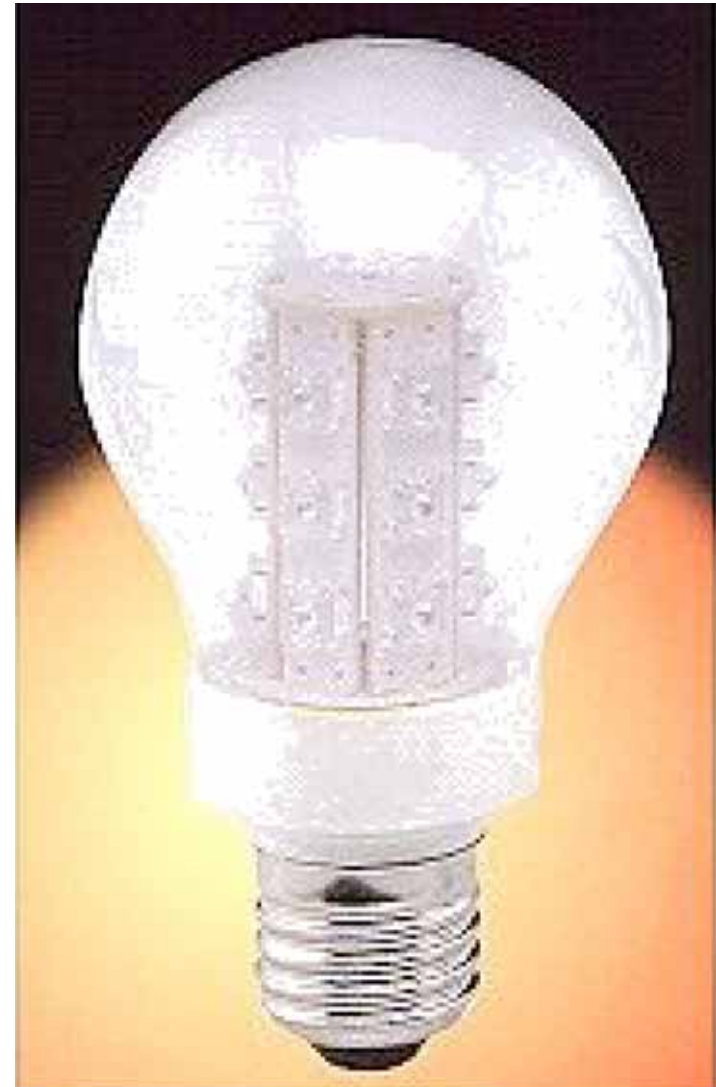
“Uses almost no energy!”

“Lasts Forever!”

Nothing will kill an industry faster than expectations that cannot be met.

Performance must be realistic and factual.

Costs must be complete.



Role of the Department of Energy

- DoE is investing wisely
 - Looking to the Past
 - Learning historical lessons
 - Looking at the Present
 - Investing in new ideas
 - Building industry, academic, and utility partnerships
 - Sponsoring Workshops -> Roadmaps -> Investments
 - Creating Energy Star guidelines
 - Supporting and driving standards
 - Looking to the Future
 - Competitions
 - Accelerating adoption

Eye on the Light

A large, illuminated Ferris wheel (the London Eye) is the central focus, glowing with vibrant, multi-colored lights (red, orange, yellow, green, blue, purple) against a dark night sky. The background shows the city of London at night, with various buildings and lights visible along the riverbank.

Thank You!